An exploration of road safety parameters in Greece and Turkey

George Yannis, Assistant Professor[1]
Alexandra Laiou, Research Engineer
Sophia Vardaki, Research Engineer
George Kanellaidis, Professor

Department of Transportation Planning and Engineering
of the National Technical University of Athens

Abstract

Given that several regions of Greece and Turkey have higher road accident death rates than any other European region, the objective of this research is the exploration of the underline parameters, which contribute to this phenomenon. On that purpose, road accident fatalities are co-examined with basic macroscopic parameters affecting road safety, like population and vehicle fleet and lognormal models are developed for Greece, Turkey and three selected groups of EU countries. The application of the models developed showed clearly that not only the rapidly increasing motorization level in both countries but mainly the highly risky two-wheeler traffic constitute main contributing factors to the increased road fatality rates in the two countries. The proposed calculation of the dimensionless elasticity for each examined parameter was found as a simple but appropriate technique for the direct comparison of different cases of parameters and models. The results of this research could be proved beneficial for the identification of specific measures addressing the underlying road safety issues in Greece and Turkey, like the increased motorcycle traffic.

Key words: road fatalities, road accidents, motorcycles, lognormal, elasticity.

---

[1] George Yannis, Assistant Professor
Department of Transportation Planning and Engineering
National Technical University of Athens
5, Iroon Polytechniou str. GR-15773, Athens, Greece
phone +30.210.7721326, fax +30.210.7721454

1. Introduction

Road accidents have become one of the major causes of death in many countries and road safety is regarded as an issue of public health. In 2004, more than 43.000 persons were killed in almost 1.3 million car accidents which occurred in the EU. About 1.8 million persons were injured, 285.000 of them seriously (CARE, 2007).

The road safety level differs a lot among the members of the European Union and the candidate countries. Three main groups can be distinguished, based on the number of persons killed per million registered passenger cars. It is noted that this ratio was chosen because of incomplete and partially non-harmonised data on the actual transport performance (expressed in passenger - kilometers). North-west countries perform best with Sweden, United Kingdom and the Netherlands having the lowest number of persons killed per million passenger cars in 2004. Countries in southern Europe (Spain, Italy, Portugal and Greece) display a clearly lower road safety level. Finally, eastern countries (members and candidates) have the highest values of the examined ratio (Bialas-Motyl 2007, ETSC 2006).

During the last decade most of the European countries have achieved an important improvement on their road safety level. In Greece and Turkey the number of persons killed per million registered passenger cars has decreased by over 50 percent in ten years (Akgüngör, 2007). Nevertheless, there is still need for further improvement in both countries. Focusing on the individual regions of the EU-25, it appears that 7 out of the 10 most dangerous regions during 2004, are located in Greece. Respectively, 18 out of the 20 most dangerous regions in the candidate countries are located in Turkey (Bialas-Motyl, 2007).

Previous studies have shown, since long, (Smeed 1949, Adams 1987) that the examined ratio is correlated with the density of car ownership and the population. Countries with high ratios like Turkey and Romania are characterised by low passenger car density. The percentage of motorcycles in the total fleet is also a parameter with an important effect on road fatalities as two-wheeler riders are at increased risk in relation to passenger car drivers (Yannis et al, 2005b, Spyropoulou et al, 2005). As far as population is examined, an increase of the population is usually related to a decrease of the accident risk (Bialas-Motyl 2007, Isildar 2006).

The objective of this research is the exploration of the basic parameters affecting road safety performance in Greece and Turkey and the comparison of road safety trends between these two neighbouring countries but also in relation to three selected groups of EU countries.

On this purpose demographic and vehicle fleet parameters were selected and the impact of each one of them to the number of road fatalities was explored. A lognormal model was developed for each country or group of countries. Dimensionless elasticities were used for the direct comparison of all model parameters, in order to identify differences and similarities in road safety performance in the countries examined.

2. Methodology

Five cases were explored in this research. These were: the cases of Greece and Turkey individually and the cases of the rest members of the E.U. divided in three groups. The group of "North-West Europe" included Austria, Belgium, Denmark, France, Germany, Ireland, Luxembourg, Sweden, the Netherlands and the United Kingdom. The group of "South Europe" consists of Spain and Italy. Finally, Cyprus, Czech Republic, Latvia, Lithuania, Poland, Slovakia, Slovenia and Romania form the group named "New members". It is noted that Finland, Portugal, Bulgaria, Estonia, Hungary and Malta were not included in the research because of lack of the necessary exposure and accident data.

The road safety level of each country or group of countries is expressed by the number of road fatalities per year. The parameters examined are the population, the total number of registered vehicles and the percentage of motorcycles in the total fleet.

Data used in the analysis come from international databases as well as from National Statistical Services when necessary. Demographic and vehicle fleet data for all countries were extracted from the Eurostat database. Data on vehicle fleet were available only for years 1985-2004. Finally, data on fatalities come from the IRTAD (period 1985-1990) and from the CARE database (period 1991-2004). National statistics were also used in order to fill in the gaps. Data cover years 1985-2004 for Greece and Turkey, 1985-2004 for North-West and South Europe and years 1991-2004 for the new members. After collecting all the necessary data, a new database was created and used for the statistical analysis.

In order to develop a statistical model which would describe the road safety level for each case, several types of models were investigated. Lognormal regression was finally selected for its simplicity but also for its adequateness for such international road safety comparisons. Five models were finally developed, each one referring to one of the countries and group of countries examined. The statistical significance of the relationship between the dependent and the independent variables was assessed by calculating the R^2 value (Mc Carthy P.S., 2001). For each independent variable, the t - value was also used as a measure of the statistical significance of each parameter (Leech et al, 2005).

In order to make possible the comparison between countries, focus was given to the estimation of the responsiveness and sensitivity of the dependent variable with respect to changes in each independent variable. On this purpose, the elasticity of each dependent variable was calculated (Washington et al, 2003). Visual presentation of results was also used for the better understanding of the impact on road safety of the macroscopic parameters examined.

3. Model development

During the development of each lognormal regression model, three independent and one dependent variable were used. The independent variables were: the number of registered vehicles (motorcycles are not included), the percentage of motorcycles in the total fleet and the population of each country or group of countries. The logarithm of road fatalities per year in each case was examined as the dependent variable. Lognormal model was selected because of the more adequate depiction of the road fatalities' time series. All five models were developed according to the following model structure:

$$y = 10^{a_0 + a_1 x_1 + a_2 x_2 + a_3 x_3} \quad (1)$$

where y: log(fatalities)

x_1 : the number of registered vehicles

x_2 : the percentage of motorcycles in the total fleet

x_3 : the population

The results of the lognormal regression for all cases are shown in Table 1.

	GREECE			TURKEY			NORTH-WEST EUROPE			SOUTH EUROPE			NEW MEMBERS		
	coeff.	t-value	elasticity	coeff.	t-value	elasticity	coeff.	t-value	elasticity	coeff.	t-value	elasticity	coeff.	t-value	elasticity
	2,476	1,287	-	4,519	9,510	-	7,671	8,030	-	8,471	6,365	-	0,474	0,151	-
total num. of regist.vehic.	-1,40E-07	-6,461	0,029	8,07E-08	1,497	0,026	1,53E-09	0,822	0,111	-1,29E-09	-0,664	0,082	2,55E-09	0,282	0,057
(%) motorcycles in total fleet	0,033	1,410	0,042	0,034	2,287	0,291	-0,039	-2,808	0,153	0,046	2,884	0,153	0,011	1,010	0,040
population	8,29E-08	0,389	0,279	-2,69E-08	-2,027	0,112	-1,31E-08	-2,847	0,636	-4,81E-08	-3,108	0,836	3,29E-08	0,948	1,509
R^2	0,777			0,791			0,940			0,780			0,747		

Table 1. Lognormal regression results for all cases.

In North-West Europe, R^2 value was calculated equal to 0,940. This value indicates a rather high statistically significant relationship between the dependent and the independent variables. For the rest of the cases, R^2 values are lower though acceptable.

All five models were depicted on one chart (Figure 1). For each case both curves for actual and model values of fatalities were drawn.

The elasticity of each dependent variable was calculated based on the formula:

$$e_i = \frac{\Delta Y_i}{\Delta X_i} \cdot \frac{X_i}{Y_i} \qquad (2)$$

where X_i: the average value of each variable x_i

Y_i: the average value of log(fatalities)

Elasticity is useful because it is dimensionless unlike any estimated coefficient of regression parameter, which depends on the units of measurement of each parameter. In this way, it is possible to express quantitatively the impact of each independent variable on the dependent. In combination with the sign (±) of the coefficients it is also possible to identify whether an increase in each independent variable results in an increase or a decrease in the independent one.

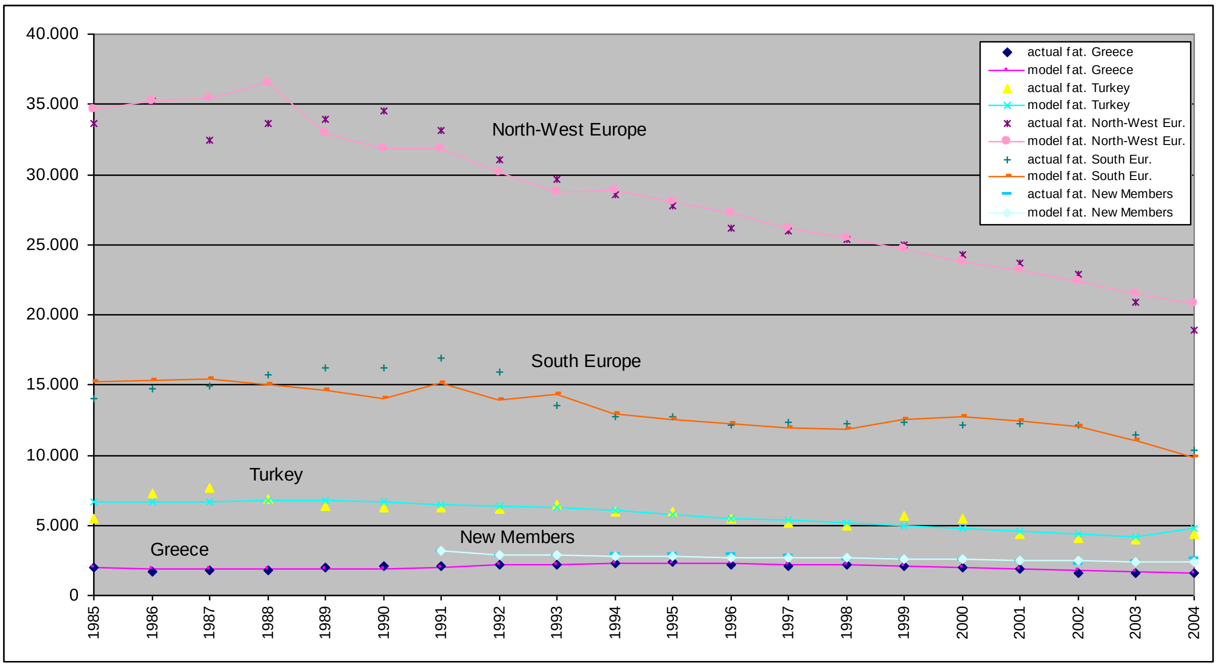

Figure 1: Actual and model values of fatalities.

4. Model application

Based on the above elasticity calculations, the five models can be further explored and compared to each other through the comparison of elasticities calculated for each case. The kind of impact that each independent variable has on the dependent variable can be identified by the sign (±) of the corresponding coefficient in each model.

In the case of Greece elasticity values are: e_1 = 0,029, e_2 = 0,042 and e_3 =0,279. These results show that the population is the variable which affects the number of road fatalities most but the percentage of motorcycles in the total fleet has also a great impact on road fatalities. An increase in the total number of registered vehicles results in a decrease in road fatalities, while an increase in the percentage of motorcycles or the population result in an increase. Specifically, a 1% increase in the population and in the motorcycles percentage result in a 0,279% and 0,042 increase respectively in the number of road fatalities. A 1% increase in the total number of registered vehicles results in a 0,029% decrease in road fatalities.

While examining the case of Turkey, it was concluded that the percentage of motorcycles in the total fleet is the one with the greatest impact on road fatalities as elasticity values were found:e_1 = 0,026, e_2 = 0,291 and e_3 = 0,112. Considering the way each independent variable affects the dependent, the results show that an increase in the total number of registered vehicles or in the percentage of motorcycles in total fleet has as consequence an increase in road fatalities while an increase in population results in a decrease. Specifically, 1% increase in the percentage of motorcycles and in the total number of registered vehicles causes respectively 0,291% and 0,026% increase in the road fatalities, whereas a1% increase in population causes 0,112% decrease in road fatalities.

The following step was the examination of the three groups of European countries. The first case was the North-West Europe. The elasticities were found: e_1 = 0,111, e_2 = 0,153 and e_3 = 0,636. In this case, population has the greatest impact in road fatalities. In this case, an increase in the total number of registered vehicles causes an increase in road fatalities. On the contrary, an increase in the percentage of motorcycles or in population causes a decrease in road fatalities.

In the case of South Europe, the population has the greatest impact on the number of road fatalities, followed by the percentage of motorcycles in the total fleet and the total number of registered vehicles. Specifically, the elasticity values for population, the percentage of motorcycles in the total fleet and the total number of registered vehicles were calculated equal to 0,836%, 0,153% and 0,082% respectively. The coefficients in this model indicate that an increase in the total number of registered vehicles or the population has as consequence a decrease in road fatalities, while an increase in the percentage of motorcycles in total fleet results in an increase of the road fatalities.

Finally, in the new members of E.U., increase of any of the three variables results in increase of the number of road fatalities, with the population being the variable with the greater impact. Elasticity values were calculated e_1 = 0,057, e_2 = 0,040 and e_3 = 1,509.

In total, it seems that population is the variable which affects most the number of road fatalities in all cases except in Turkey, where the highest impact comes from the percentage of motorcycles. In contrast, the total number of registered vehicles seems to be the variable with the smaller impact on road fatalities. Furthermore, it was found that the increase in the percentage of motorcycles leads to the increase of road fatalities in all cases except in the developed countries of the North Western Europe.

Furthermore, from the comparison of the elasticities for each case it was found that in Europe of 15 (Greece, North-Western and Southern Europe) there are similarities concerning the order of variables based on the impact each one has on road fatalities; in order of importance: population, percentage of motorcycles and vehicle fleet.

5. Conclusions

Greece and Turkey perform worse in road safety among the European countries, with most of the most dangerous regions for the year 2004, being located in these two countries. The objective of this research was the exploration of the basic parameters affecting road safety performance in Greece and Turkey and the comparison of road safety trends between these two neighbouring countries but also in relation to three selected groups of EU countries. On this purpose, lognormal regression was applied to vehicle fleet and demographical data. A lognormal model was developed for each case and elasticity values were calculated for each variable. The examination of all cases was based on the comparison of elasticity values within and between groups.

The proposed calculation of the dimensionless elasticity for each examined parameter was found as a simple but suitable technique for the purposes of this research, allowing the direct comparison of different cases of parameters and models. A single model for all cases should have been more accurate but definitively more difficult to develop and well more complicated to analyse, especially when all countries and groups of countries have not the data available for the same period. Furthermore, using elasticities was found adequate for the comparison of the basic road safety parameters not only between the two countries in question but also in relation to the selected broader groups of European countries - and not with each one country separately that a single model would impose.

The examination of Greece and Turkey, individually, revealed that there are some important road safety similarities between the two countries. In both cases, an increase in the percentage of motorcycles in the total fleet results in an increase in road fatalities, as expected for the less developed countries with high percentage of motorcycle traffic (Yannis et al., 2005a). Consequently, successful road safety measures implemented for years in the North Western European countries may not be the most appropriate for the Southern countries and research should focus on measures addressing properly the motorcycle traffic risk particularities of these countries.

It was also shown that road safety in Greece and Turkey has more similarities with road safety in the Southern countries than with the other groups (North-Western, New members) of EU countries. Another interesting finding was that population does have an important impact on road fatalities' trends in all EU countries - with the exception of Turkey - demonstrating as expected that road safety is primarily correlated to basic macroscopic socio-economic developments of the modern societies.

The results of this research revealed the role of basic parameters for the road fatalities' macroscopic trends, a very useful information for all decision makers designing the national road safety policies (Kanellaidis et al., 2005). Common characteristics of neighbouring countries may dictate similar road safety performance, a useful hint for all those who attempt to identify future road safety trends and propose countermeasure policies. It is obvious that among the parameters examined, some can be more useful for the design of policies and countermeasures (vehicle fleet, motorcycle percentage) and some others are useful mainly for macroscopic estimations (population).

Certainly, road safety trends can be attributed to various parameters, some of which can be modeled explicitly (population,. vehicle fleet, motorcycle percentage, etc.), while others may be handled indirectly due to lack of the necessary data (traffic, driver behaviour etc.). Further research comprising more parameters, more complete time series data and exploration of alternative and/or more complex models could be proved beneficial for the identification of future road safety trends through the respective performance of neighbouring countries. Especially for the parameter "population" it would be useful to examine various behavioural aspects of different population groups (pedestrians, older drivers, etc.) and their safety impact in the various countries with different road user behavioural patterns.

REFERENCES

1. Adams J. (1987), J. Smeed's law: Some Further Thoughts. Traffic Engineering and Control, Vol. 28, No. 2, pp.70-73.
2. Akgüngör A.P. (2007), Road traffic accidents and safety programme in Turkey. International Journal of Injury Control and Safety Promotion, Vol. 14, No. 2, pp.119 -121.
3. Bialas - Motyl A. (2007), EU road safety 2004: Regional differences. Statistics in focus, Transport, 14/2007.
4. CARE, European Road Accident Database http://ec.europa.eu/transport/roadsafety/road_safety_observatory/care_en.htm.
5. European Transport Safety Council (ETSC) (2006), Road Accident Data in the Enlarged European Union, Learning from each other.
6. EUROSTAT, http://epp.eurostat.ec.europa.eu
7. IRTAD, International Road Traffic and Accident Database, http://cemt.org/IRTAD/IRTADPublic/index.htm
8. Isildar S. (2006), Road Accidents in Turkey 1995-2004. IATSS Research, Vol.30 No.2, pp.115-118.
9. Kanellaidis G., Yannis G., Vardaki S., Dragomanovits A., Laiou A. (2005). Development of the 2nd Strategic Plan for the improvement of road safety in Greece. Paper presented at the 3rd Panhellenic Road Safety Conference, Patra, October 2005.
10. Leech N.L., Barrett K.C., Morgan G.A. (2005), SPSS for Intermediate Statistics, Use and Interpretation, 2nd Ed, Lawrence Erlbaum Associates, New Jersey.

11. Mc Carthy P.S. (2001). "Transportation Economics Theory and Practice: A Case Study Approach", Blackwell, Boston, MA.
12. National Statistical Service of Greece, Annual Statistical Reports.
13. Romanian Statistical Institute (2005), Statistical Yearbook.
14. Smeed R.J. (1949). Some statistical aspects of road safety research. Royal Statistical Society, Journal (A), CXII (Part I, Series 4), pp.1-24.
15. Spyropoulou I., Papadimitriou E., Yannis G., Golias J. (2005) "Causes and countermeasures of two-wheel accidents". Paper presented at the 3rd Panhellenic Road Safety Conference, Patra, October 2005.
16. Turkish Statistical Institute (2006), 1923 - 2005 Statistical indicators.
17. Washington S.P., Karlaftis M.G., Mannering F.L. (2003), Statistical and Econometric Methods for Transportation Data Analysis, Chapman & Hall / CRC Press, Boca Raton, FL.
18. Yannis G., Golias J., Papadimitriou E., (2005a) Driver age and vehicle engine size effects on fault and severity in young motorcyclists' accidents. Accident Analysis and Prevention, No.37, pp.327-333.
19. Yannis G., Golias J., Papadimitriou E., Spyropoulou I. (2005b) "Passenger car and two-wheel drivers risk analysis in Greece". Paper presented at the 3rd Panhellenic Road Safety Conference, Patra, October 2005.